NATIONAL BUREAU OF STANDARDS REPORT

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Progress Report

on

USE OF IONIZATION CHAMBERS IN OBTAINING DATA ON RADIATION AT POINTS WITHIN THE HEAD DURING DENTAL X-RAY EXPOSURE

by

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U. S. DEPARTMENT OF COMMERCE
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U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

USE OF IONIZATION CHAMBERS IN OBTAINING DATA ON RADIATION AT POINTS WITHIN THE HEAD DURING DENTAL X-RAY EXPOSURE

Abstract

A study to determine levels of ionizing radiation at various points in and about the human head during dental radiography was undertaken. A phantom of tissue-equivalent wax was built around an adult human skull, and measurements were made using small Sievert ionization chambers placed at the skin and within the skull at ten different locations.

Radiation absorbed during full-mouth intra-oral dental radiography using conventional 8" skin-target distance, 65 KV and 10 ma with 1.5 mm of aluminum filtration, and exposing 14 films, was measured. Dosage at the skin of the cheek amounted to 20-25R and various lower values were obtained at other points within the head.

A comparison of these radiation levels was made with measurements taken at the same points in the head when using a panoramic extra-oral radiographic technic. Maximum dosage in this technic occurred in the lymphatic region of the neck and a reading of .42R was recorded there during full-mouth exposure. Levels within the skull ranged downward from this value.

1. INTRODUCTION

A project at the Dental Research Laboratory, National Bureau of Standards, sponsored by the U. S. Air Force Dental Service, is concerned with the development of a device for making extra-oral full-mouth panoramic dental X-ray exposures. In connection with this project, it was desired to determine levels of radiation produced at various points in and about the head using the panoramic device. For purposes of comparison, measurements were also desired that would indicate radiation levels existing during full-mouth exposure using conventional dental X-ray technic.

2. APPARATUS EMPLOYED

Since the panoramic method employs a narrow beam of X-rays in making exposure, an ionization chamber of small volume was required. Such a device was found in the Sievert ionization chamber [1,2], which has an air volume slightly in excess of 30 mm, and a physical size which was easily accommodated in the specimens to be irradiated. The Sievert chamber (Fig. 1 and 2), is a condenser-type R meter, having a wide range of sensitivity dependent upon the charge applied, and can be relied upon to produce measurements accurate to within ± 10% at the energies used in this experiment. All voltage measurements after charging and after exposure to radiation were made using the Kiethley Electrometer. Using calibration curves previously prepared for each chamber, and corrections for atmospheric pressure and humidity, radiation levels to which the chambers had been exposed were calculated.

The X-ray source was a standard radiographic unit, operated at 65 KV and 10 ma, having $\frac{1}{2}$ mm Al. equivalent inherent filtration,

to which was added 1 mm Al. The quality of the radiation was 18-20 KEV, calculated from its absorption coefficient.

A wax phantom head was constructed about an adult human skull. The wax was of tissue-equivalent density to X-rays and consisted of a mixture of 50% paraffin and 50% beeswax by weight to which was added .5% by weight of rosin [3]. The phantom was constructed to permit access to points within the head for the placement of the ionization chambers (Fig. 3 and 4).

3. EXPERIMENTAL METHOD

Ten points were chosen at which to measure radiation levels. Several of these were chosen because they are located in areas rich in lymphoid or glandular tissue. Points at which overlap or intersecting planes of radiation might be expected were also included. These points were: (1) at the skin of the neck when using the panoramic exposure and at the skin of the cheek when using conventional exposure; (2) in the region of the sella turcica; (3) in the region of the parotid gland; (4) in the sublingual region; (5) in the center of the base of the tongue; (6) in the cornea of the eye; (7) in the region of the thyroid gland; (8) in the deep cervical lymphatic region; (9) in a lower bicuspid tooth socket; and (10) at a point just posterior and medial to the lower third molar tooth. The last-mentioned location was included since the axis about which the beam of X-rays was rotated during panoramic exposure passed through this point. It was desired to determine if any excessive concentration of radiation occurred at this center of rotation.

Rate of delivery from the filtered X-ray source was approximately 558 mr/sec in air at 12" from the target when using the slit or narrow

beam in the panoramic technic, and about 647 mr/sec in the air at the same distance when using a round cone of rays for the conventional intra-oral technic. Delivery rates were measured using the Sievert chambers.

Skin-target distance was 8" when employing the standard intra-oral 14 film radiographic method and varied from 8" to 12.5" depending on the position of the X-ray source at any given time in its cycle of motion about the head during radiography by the panoramic method. Total exposure time was 25 sec. with the panoramic technic and 40.5 sec. with the intra-oral method.

In each full-mouth exposure included in this experiment, the conditions that would exist during actual clinical practice were adhered to. Standard lead-backed dental films (Eastman Radiatized) were positioned in the phantom for each single exposure by the conventional technic. One series of 14 exposures was found to be sufficient to produce radiation levels at all measuring points falling within the range of the ionization chambers. It was necessary to repeat the exposure ten times when using the panoramic method in order to obtain levels of radiation that could be reliably measured, using the same chambers.

Total skin-surface area exposed to radiation at any point in the exposure cycle using the panoramic method, amounted to less than one square inch. During exposure by conventional methods, approximately 12 square inches of skin area were irradiated during each individual film exposure and overlapping of irradiated areas is unavoidable during a series of films required for full-mouth radiography.

4. RESULTS

Levels of radiation measured at the points selected are graphically displayed in Figure 5. It will be noted that under the conditions of this experiment, the highest level of ionizing radiation during full-mouth radiographic exposure using the panoramic technic existed in the cervical lymphatic region of the neck and amounted to .42R. The highest levels of radiation when using conventional intra-oral radiographic technic, existed at the skin of the cheek and in the region of the thyroid gland, where 23 and 27 R, respectively, were recorded.

5. SUMMARY

Levels of ionizing radiation produced at points in and about a wax phantom of the human head, were measured during full-mouth dental radiography by a panoramic method and by a conventional 14-film intra-oral technic. The panoramic method was found to produce radiation levels approximately 1/50th as intense as those recorded at comparable points when using conventional dental radiographic technic.

6. ACKNOWLEDGEMENT

The authors wish to express their appreciation to the personnel of the Naval Medical Research Institute, Bethesda, Maryland, for their cooperation in furnishing the ionization chambers and in charging and measuring voltages on the chambers during this experiment. Lt. James W. Duckworth and Lt. (JG) Robert Sharp rendered most valuable service in performing the above mentioned technical procedures.

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3. Hasterlik, R. J., Argonne Cancer Research Hospital, Chicago, Illinois, (Personal communication).

Figure 1. Sievert ionization chamber, showing small size.

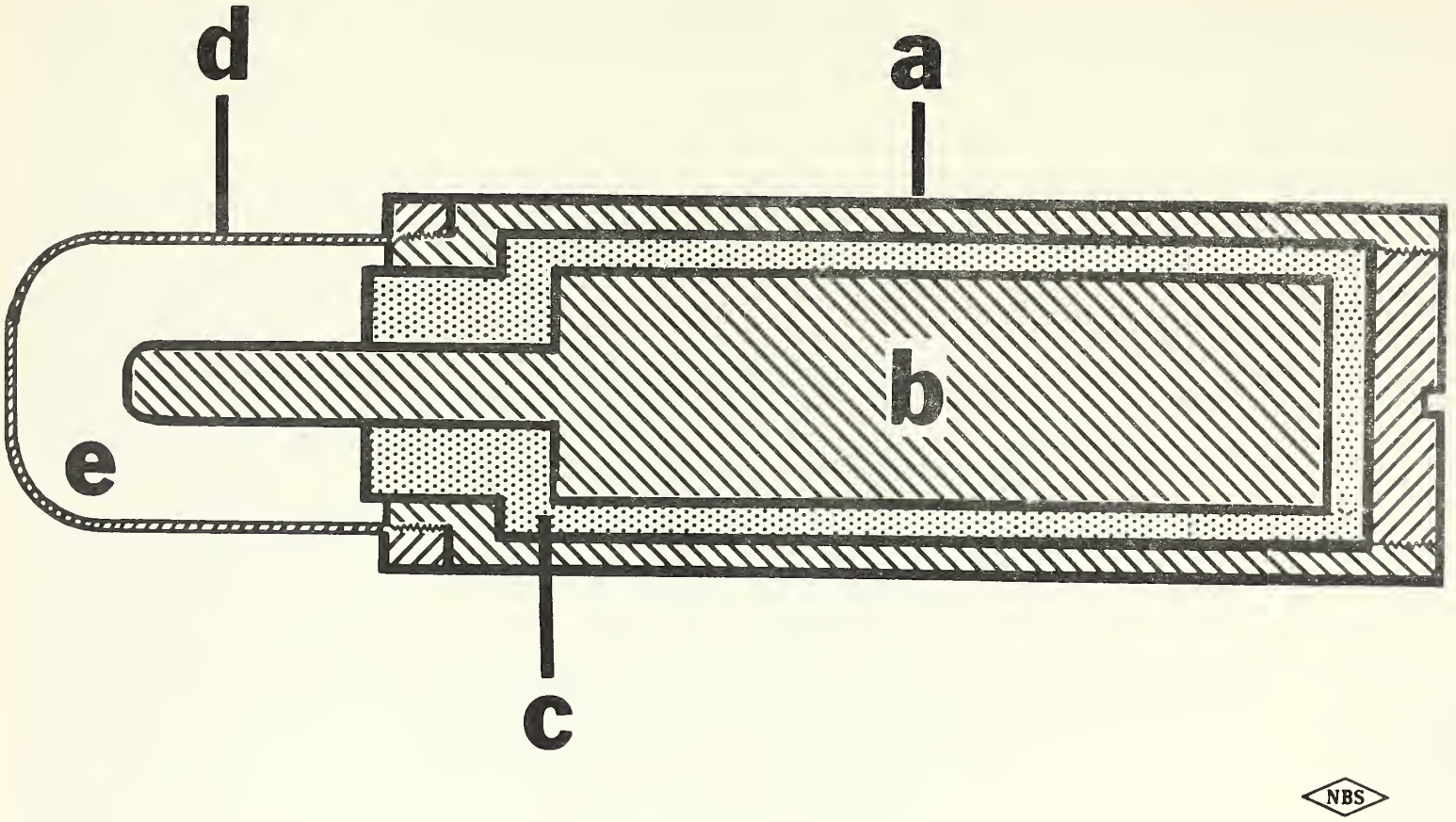

Figure 2. Sievert ionization chamber.
(a) Outer shell.
(b) Inner condenser element with antenna.
(c) Dielectric.
(d) Thin-walled cap.
(e) Air chamber.

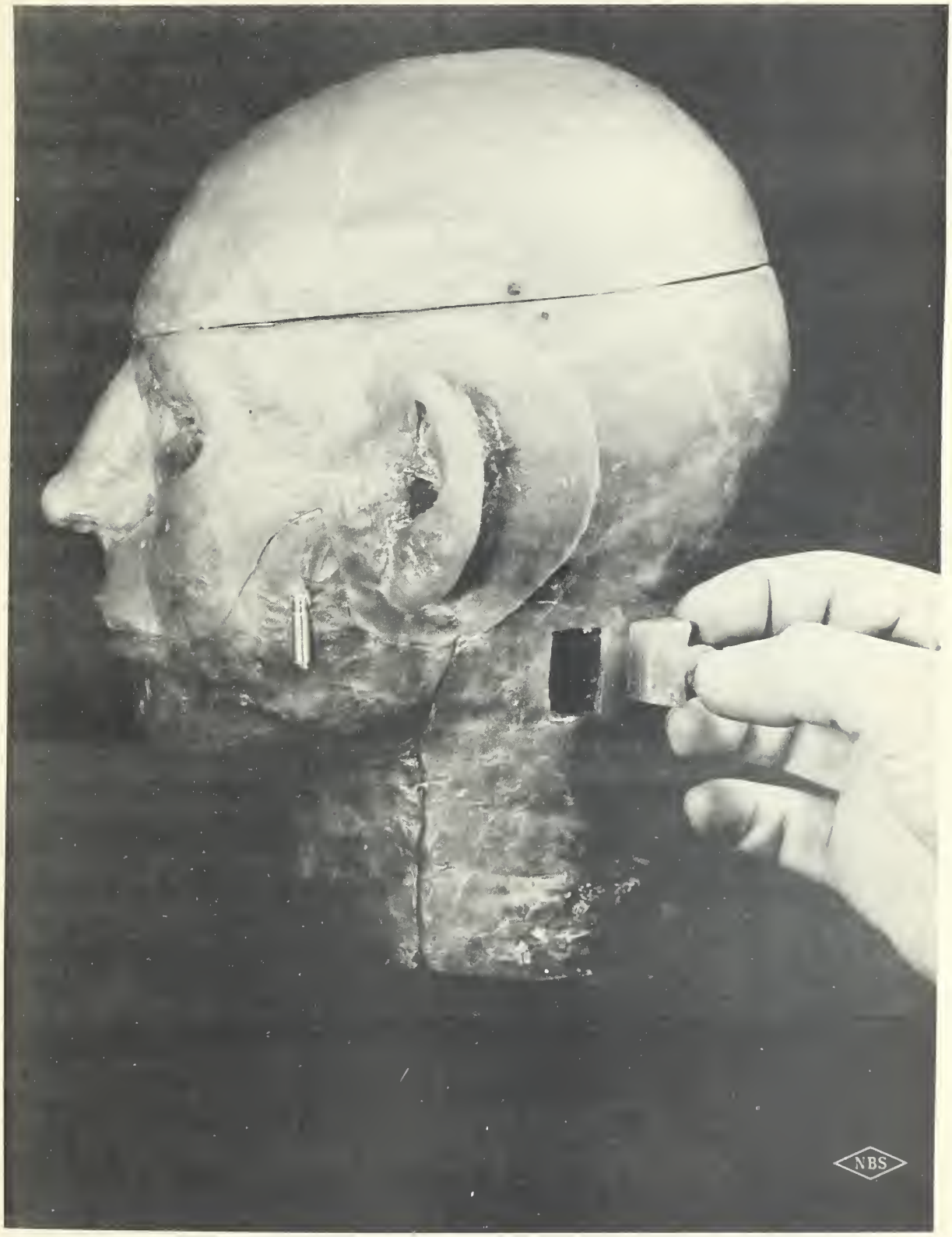

Figure 3. Wax phantom showing placement of ionization chamber at skin of cheek and recessed location for measurements in region of neck lymphatics.

Figure 4. Wax phantom disarticulated for placement of ionization chambers at internal points.

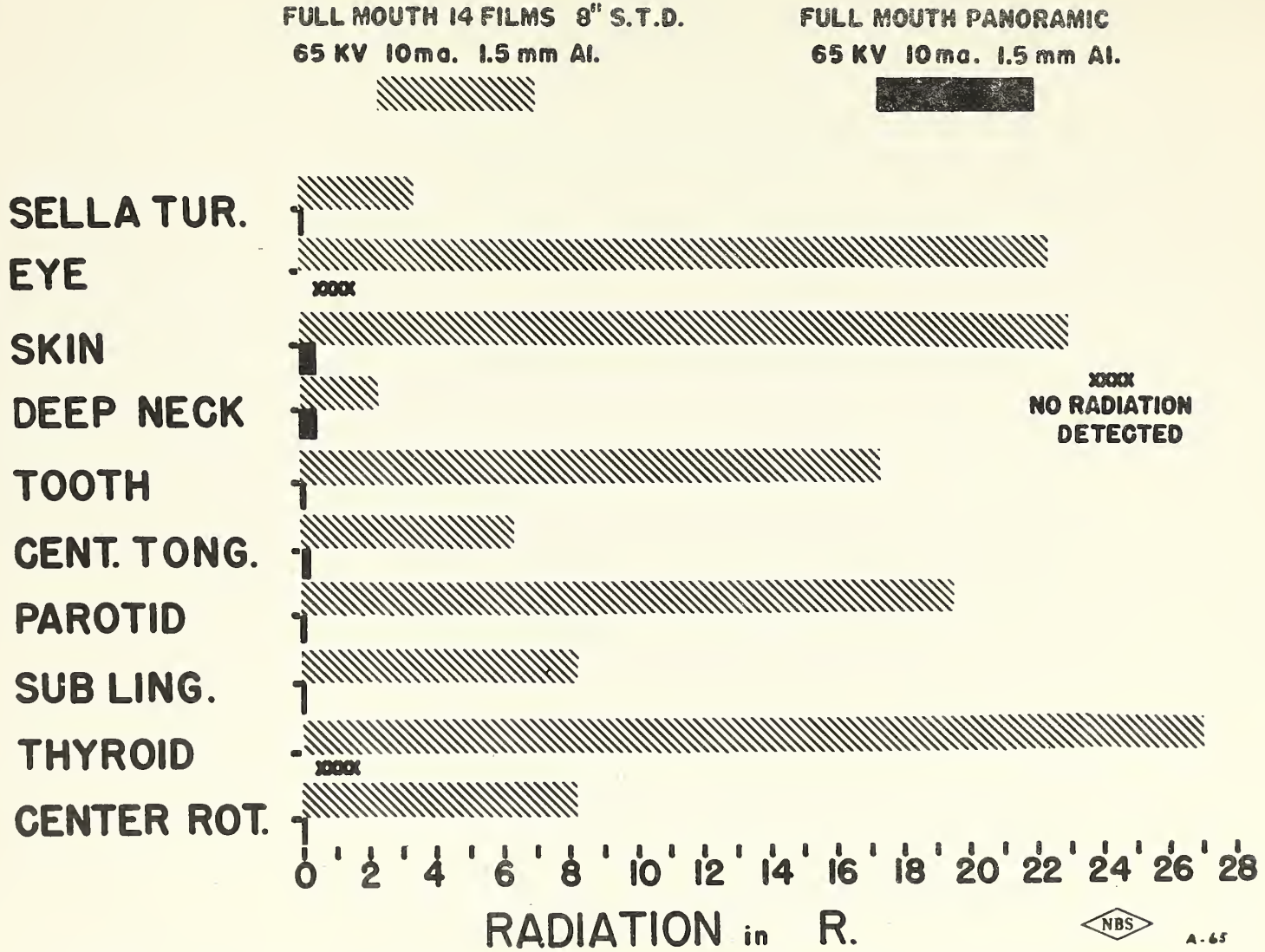

Figure 5. Chart showing levels of radiation measured at 10 selected points in and about the human head phantom, using a conventional and panoramic full-mouth radiographic technic.

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Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office. Inquiries regarding the Bureau's reports and publications should be addressed to the Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.


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